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Eric M. Bruton

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*Grinding Sintered Carbide, Especially Sintered Carbide Cutting Tools, with Diamond Grinding Wheels**

by

G. Pahlitzsch and G. Rafflenbeul

Summary

Grinding speed and surface pressure, or force of pressure, have a great effect on the results of grinding sintered carbide with diamond grinding wheels.

With a bronze-bonded diamond grinding wheel, the increase of grinding speed v_s and of the surface pressure p results in an almost linear rise in abrasion, and an increase in the grinding speed has about twice as much effect as an increase in the surface pressure. In both cases the absolute wear of the grinding wheel increases, but the specific wear becomes less, *ie* with an impregnated grinding layer of a certain thickness, the greatest amount of abrasion of sintered carbide will be obtained if a high grinding speed and high surface pressure are used. The grinding speed and surface pressure have less effect on the surface finish of the ground sintered carbide surfaces and on the smoothness of the sintered carbide cutting edges, because in connexion with these it is most of all the grinding time, that is the length of use of the grinding wheel after truing, which is of significance.

Rising grinding speed and surface pressure cause an increase in abrasion of the sintered carbide with resin-bonded diamond grinding wheels also, but here the influence of the surface pressure is considerably greater than that of the grinding speed, the alteration of which has only

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a slight effect. A limit is set for the surface pressure by the capacity of the wheel. The absolute wear increases with the grinding speed, almost linearly, and also the specific wear becomes considerably greater. Increased surface pressure, on the other hand, raises the absolute wear relatively little, and allows the specific wear to drop, as long as it does not come too close to the loadability limit of the K wheel. Surface finish and cutting edge smoothness have their most favourable values with small grinding speeds, and are independent of the surface pressure. The best results are obtained on a K wheel with small grinding speeds and medium surface pressures.

1. Introduction

In support and extension of earlier research work,[1] further experiments have been carried out recently, from which the results concerning the influence of the grinding speed and the surface pressure (or pressing force) will be the chief subject of this article, after a short general discussion. The effect of other influencing factors will be examined in a later report.

The satisfactory working of a cutting edge, with regard to good shape, surface finish of chip, and free-face and smoothness of the cutting edge, is of decisive importance for the economical use of a tool, because the properties named influence both the life of the tools, the surface finish, and the dimensional accuracy of the workpiece. Sintered carbide tools are best worked with diamond grinding wheels. The previous article gives information about the behaviour of these wheels on the basis of numerous experiments.[1] The correct evaluation of the grinding process requires several measurements, namely those of the abrasion of the workpiece, the grinding wheel wear, the finish of the polished surface, the smoothness of the cutting edge, and the surface temperature of the grinding wheel and workpiece.

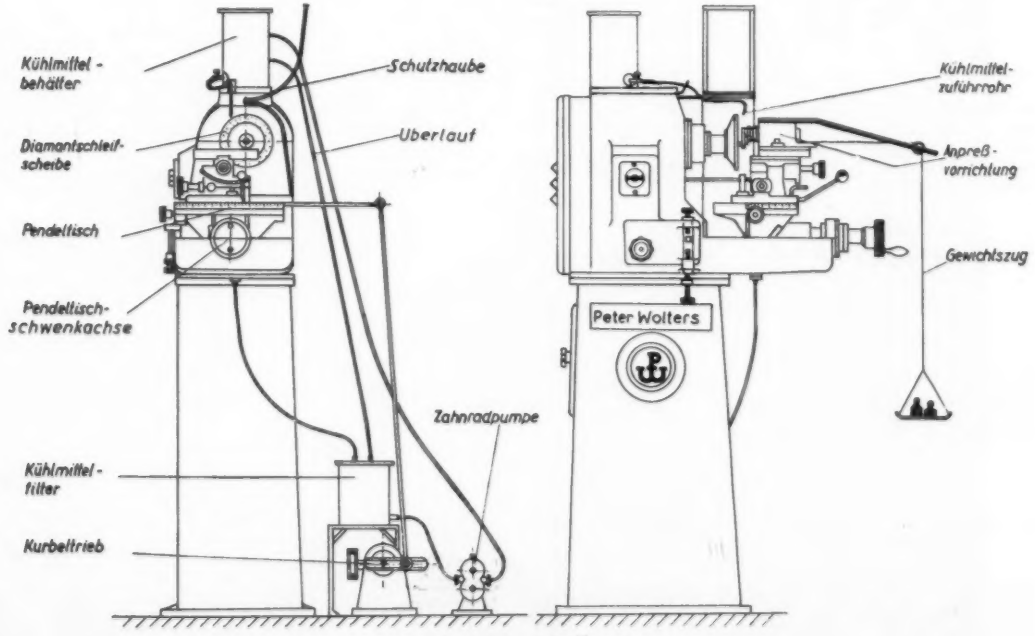
2. Apparatus and experimental method

2.1 *Grinding machine and equipment*

For the grinding, a masonry drill precision grinding and lapping machine Model ST 2[2] was used, on which the grinding spindle drive ran

Fig 1. Masonry drill precision grinding and lapping machine ST 2 with holding and pressure device for sintered carbide plates, coolant container, and protective cover.

Translation: *Kuehlmittelbehaelter = coolant container; Diamantschleifscheibe = diamond grinding wheel; Pendeltisch = oscillating table; Pendletisch-schwenkachse = swivel axis of table; Kuehlmittelfilter = coolant filter; Kurbeltrieb = connecting-rod assembly; Schutzhaube = protective cover; Ueberlauf = overflow; Zahnradpumpe = geared pump; Kuehlmittelzufuehrrohr = feed pipe for coolant; Anpressvorrichtung = pressure equipment; Gewichtszug = pulley.*



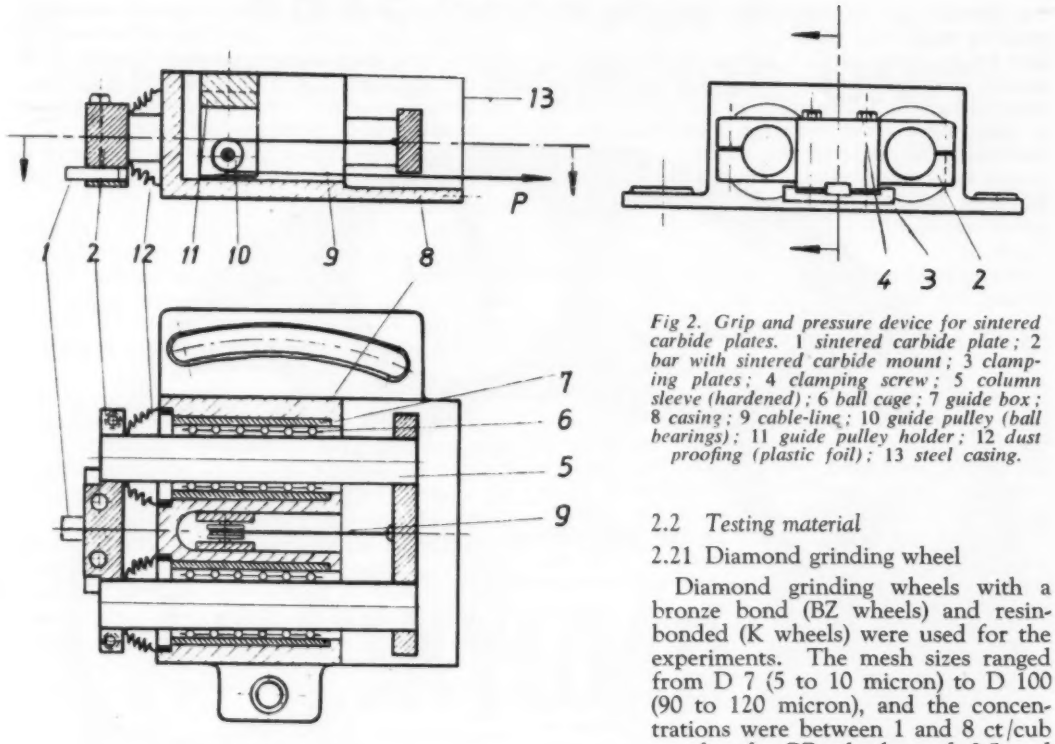


Fig 2. Grip and pressure device for sintered carbide plates. 1 sintered carbide plate; 2 bar with sintered carbide mount; 3 clamping plates; 4 clamping screw; 5 column sleeve (hardened); 6 ball cage; 7 guide box; 8 casing; 9 cable-line; 10 guide pulley (ball bearings); 11 guide pulley holder; 12 dust proofing (plastic foil); 13 steel casing.

over a V-belt pulley. The highest speed of rotation which could be reached was n_s= 4,060 rev/min. This signified, with the diamond grinding wheel measurements given in para. 2.21, a grinding speed of v_s= 24 m/sec in the middle of the grinding disk.

The sintered carbide workpiece to be ground was held in a chuck and pressed against the grinding wheel with a constant force produced by a weighted pulley mechanism operating on ball bearings. This process is suitable for grinding a drill by hand. The movement of the workpiece at right angles to the grinder was effected by a rigid connexion to the crank operating the oscillating table of the grinding machine.

The coolant was filtered after leaving the grinding position, and was returned by means of a gear pump into a tank, which had an overflow fixed to the machine. In this way regular flow of liquid was ensured. The coolant flowed in a thin stream of about 300 cub cm/min on to the grinding place. Illustrations 1 and 2 show the construction principle of the testing stand and pressing apparatus.

2.2 *Testing material*

2.21 Diamond grinding wheel

Diamond grinding wheels with a bronze bond (BZ wheels) and resin-bonded (K wheels) were used for the experiments. The mesh sizes ranged from D 7 (5 to 10 micron) to D 100 (90 to 120 micron), and the concentrations were between 1 and 8 ct/cub cm for the BZ wheels, and 0.5 and 4 ct/cub cm for the K wheels (1 carat = 0.2 g). In a few cases, S wheels (special metal bonds) were also used. With these wheels, however, the active layer consisted only of a film of diamonds which were galvanically bonded.

All grinding wheels were cup wheels; outer diameter D_s = 125 mm, grinding surface width B = 12.5 mm.

The experiments which will be described relate only to BZ and K wheels with equal diamond grain size and concentration respectively.

2.22 Sintered carbide plates

Cutting plates of the type S 1 (shape C 25; measurement 25 × 14 × 7 mm; DIN 4966) were used for the testpieces, the small edge of which was being ground (minor cutting edge). The ground surface had a section of about 13 × 7 mm which takes account of the distortion produced by the clearance angle. In order to eliminate the influence of the surface finish of the chip surface on the smoothness of the cutting edge, the top surfaces of the plates were lapped with Diaplast [3] (mesh size: M 1 micron) and had a surface finish of R_t < 0.05 microns. Grinding, as is customary,

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was directed against the cutting edge. The front grinding angle was chosen as $\beta = 90°$. To see how far the front angle β influences the grinding results, further tests were conducted. The sintered carbide plates were in three coded lots, as they came from different manufacturers or batches. They differed very slightly as to specific weight and composition. The specific weight for the three batches was as follows: A: 10.2 ± 0.2 g/cub cm; B: 10.4 ± 0.2 g/cub cm; C: 10.6 ± 0.2 g/cub cm.

For one experiment the sintered carbide types F1 and H2 were also considered.

2.3 *The experimental process*

The diamond grinding wheels were dressed before each experiment with a dressing stone so as to ensure like conditions for every test. For the BZ wheels a corundum stone, hardness J, 180 mesh, was used, and for the K wheels a synthetic pumice stone No 3 I was used. The thickness of surface removed was approximately 20-40% of the average grain of the respective grinding wheel, that is with a mesh of D 50 the layer to be removed for restoration had a thickness of about 10-20 micron. The out-of-roundness of the wheels was below 20 microns.

The grinding wheel wear was calculated by measurement of the wheel thickness before and after each experiment. However, the sintered carbide abrasion, the surface finish of the sintered carbide surface, the smoothness of the cutting edge, and the temperature of the wheel and workpiece were measured at intervals, in order to obtain data concerning the degree of blunting on the grinding wheel.

2.4 *Measurement statistics, methods of measuring, and accuracy*

2.41 Abrasion of sintered carbide.

Sintered carbide abrasion: A in grammes or in cub mm, or alternatively A' in mg/min.

For this purpose an analysis scale (Sartorius) was used, which had a weighing accuracy of 0.1 milligrammes. In the calculation of the abrasion volume in cub mm an error of ± 2% can occur, as a tolerance of ±2 g/cub cm is allowed to the manufacturers of sintered carbide.[2]

2.42 Grinding wheel wear

Thickness of grinding surface removed :
ΔH_s in micron
Volume of surface removed:
V in cub mm
Specific grinding wheel wear:
$S = V/A$ in cub mm/cub mm

In order to establish the thickness of the grinding surface which was removed, the grinding wheel was tested before and after each experiment on a Carl Zeiss optimeter turning table fitted with guides, and its thickness measured at six points on the periphery. The value of the thickness of the grinding surface removed, ΔH_s, was assessed to an accuracy of about ± 0.25 micron.

From all the values taken in the course of the experiments, the following errors for ΔH_s or V were found.

With BZ wheels the largest error was about ± 30% when $\Delta H_s \approx 0.8$ micron, while the smallest error could be taken around ± 3%, where $\Delta H_s = 8$ micron. In the majority of cases the wear ΔH_s was found to be between 3 and 6 micron, where the error lay around ±8 to 4%.

With K wheels the extreme values lay at $\Delta H_s \approx 1.5$ micron to $\Delta H_s \approx 35$ micron, which means that error can occur between about 16% and 0.7%. Most frequently ΔH_s values are between 10 micron and 20 micron, which can result in errors of about 2.5 to 1.20%.

The larger errors in BZ wheels, compared with those in K wheels, are caused by the fact that the absolute wear H_s is relatively small in BZ wheels. For the specific grinding wheel wear S, the possible errors given above must be increased by a further 2%, which can arise from the variations in specific weight of the individual sintered carbide disks. The errors are valid for individual measurements. As, however, the results are always worked out when up to five experiments have been conducted, the errors obtained from an average of the results provided are smaller.

2.43 Surface finish of the ground sintered carbide surface : R in micron.

2.44 Smoothness of the cutting edge: R_k in micron.

For these measurements a microgeometer (Hahn & Kolb) was used. The surfaces were explored with a diamond stylus and the cutting edges with a diamond edge, both having a point or cutting radius of about 10 micron. From the graphs of the sections which were taken with a light spot recorder it appeared that the angles of the grooves and scratches were mostly between 160 and 170°. If a triangular profile is assumed to be the basic form of the grooves (scratches), the stylus edge cannot quite reach the bottom of the groove (scratch) because of its round shape. The consequent errors of testing are somewhere between −30% and −8% for R, or $R_k = 0.5$ micron, and between −4% and −1% for R, or $R_k = 4$ micron. Comparisons with other measuring instruments (Perth-O-Meter, Leitz-Forster-Geraet, Interferenz-Mikroskop) show good agreement.

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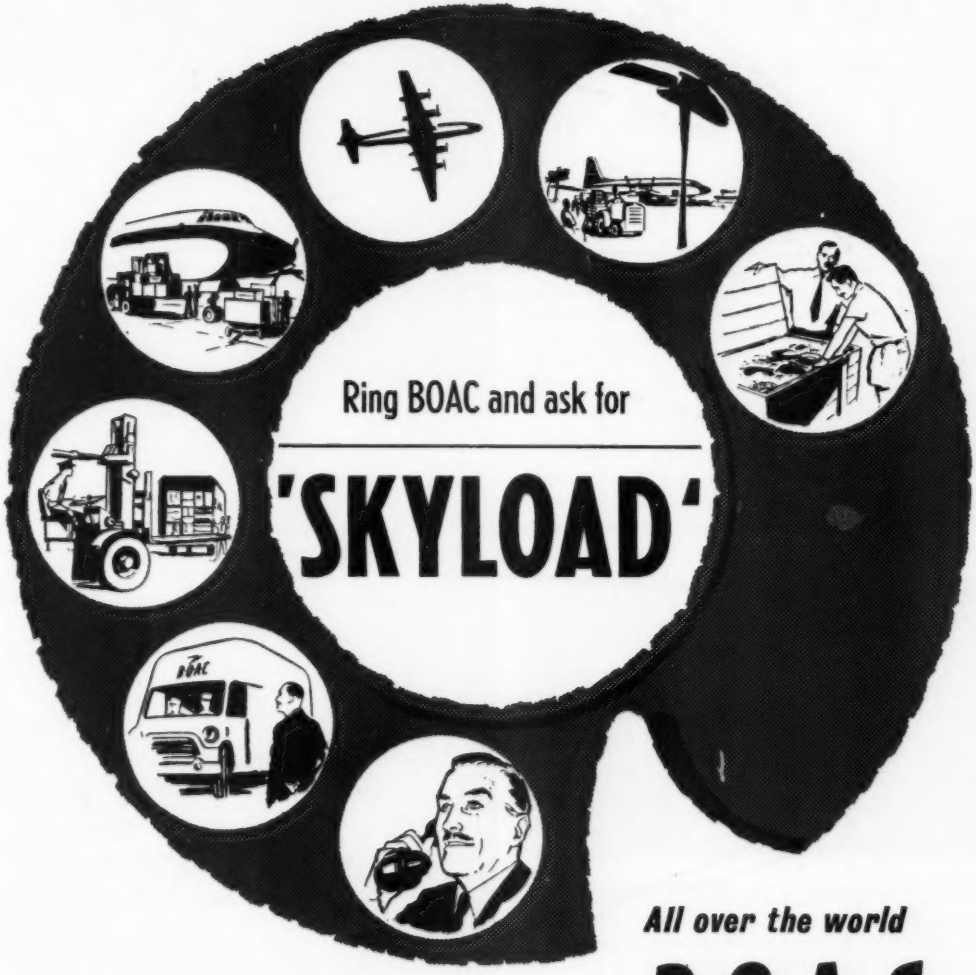

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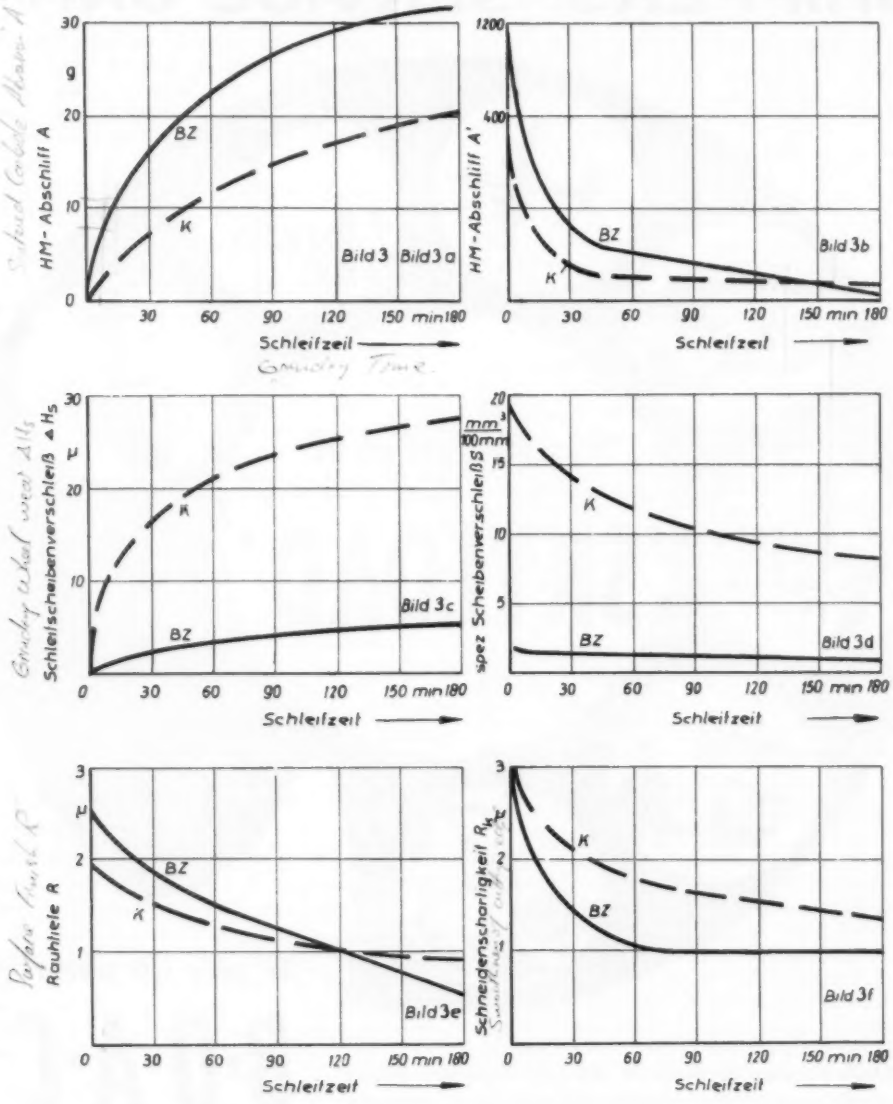
3. Survey of research carried out so far

The grinding properties of a diamond grinding wheel are dependent apart from other determinant factors, above all on the grinding time, that is, on the time the wheel has been in use after the last truing. In order to examine the



D-Körnung: D50, D-Konzentration 2ct/cm³, HM-Sorte H2, Schneidkeilwinkel β 90°
Schleifgeschw. 18,4 m/s, Anpreßkraft 1600g, Flächenpressung ~ 20g/mm²

Fig 3. *Sintered carbide abrasion, grinding wheel wear, surface finish, and smoothness of cutting edge in relation to the grinding time for bronze- and resin-bonded wheels.*

Translation: *HM-Abschliff A = sintered carbide abrasion A; Schleifscheibenverschleiss Δ H_s = grinding wheel wear ΔH_s; Schneidenschartigkeit R_K = smoothness of cutting edge R_K; D-Koernung: D50 = D mesh: D 50; D-Konzentration: 2 ct/cm³ = diamond concentration: 2 ct/cub cm; HM Sorte: H2 = type of sintered carbide: H2; Schneidkeilwinkel β: 90° = cutting rake angle β: 90°; Schleifgeschw.: 18.4 m/s = grinding speed: 18.4 m/sec; Anpresskraft: 1600g = pressure 1600 g; Flaechenpressung: ~ 20 g/mm² = surface pressure: ~ 20 g/sq mm.*

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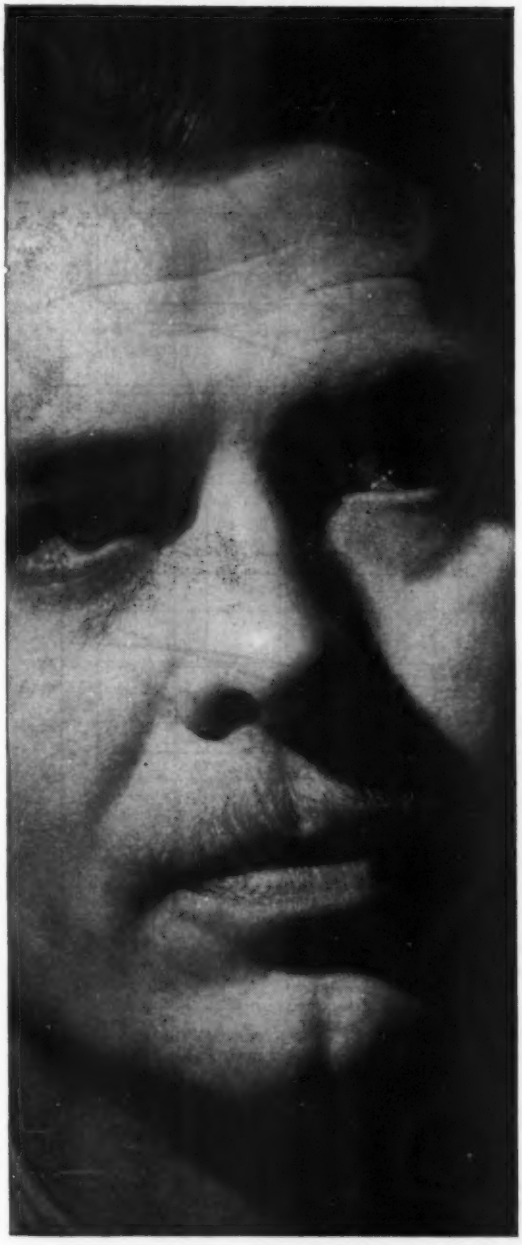
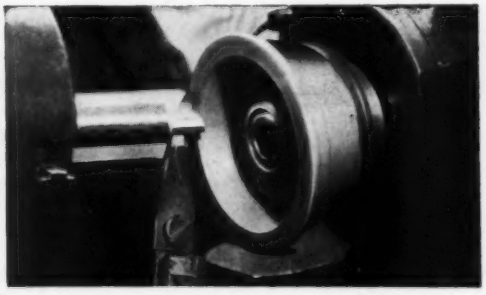


"We get more jobs out of each wheel with these" says **Tom Swain**

Tom Swain is the charge-hand of the cutter-grinding shop of Jonas & Colver (Tools) Limited. Most of the tools they grind there go to the motor industry or the aircraft industry. Among the most successful production tools that Tom's men use are the resin-bonded diamond wheels made by CARBORUNDUM shown in our smaller illustration. 'We find we get more jobs out of each wheel with these.' Tom says, 'And that's important with diamond wheels. Diamonds cost money!' He might have added that long wheel-life saves time spent in wheel changing, and so increases the production rate — not a big increase, but worth something in the course of a year.



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conditions, the grinding wheel surface and the grinding swarf are examined microscopically, as well as the measurements of sintered carbide abrasion, wheel wear, roughness, and scratch depth. Fig 3 shows the abrasion, the wear, etc, in relation to the grinding time of BZ and K wheels. A dressed wheel is very keen at the beginning of the grinding (Fig 3B) but also very liable to wear (Fig 3C and 3D). Thus the curves of all measurements have a steep gradient, which

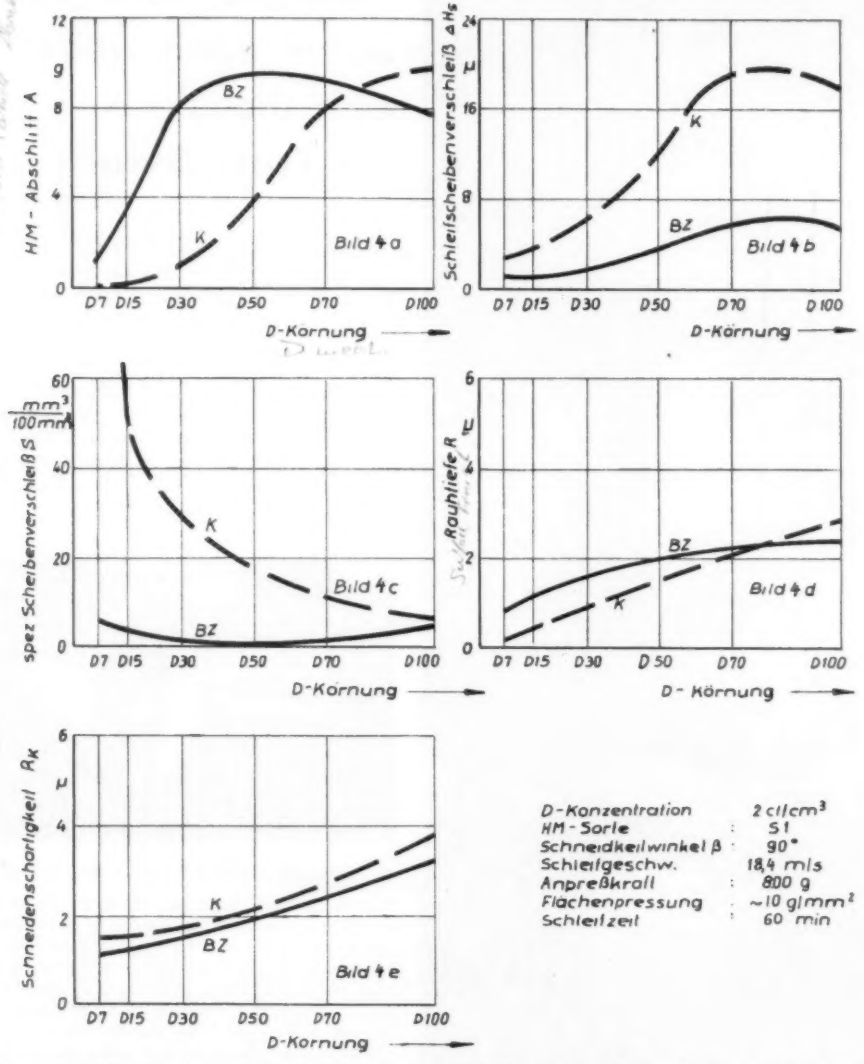

Fig 4. Sintered carbide abrasion, grinding wheel wear, surface finish, and smoothness of edge in relation to the diamond mesh size for bronze- and resin-bonded diamond grinding wheels.

Translation: *HM-Abschliff A = sintered carbide abrasion A; spez. Scheibenverschleiss S = specific grinding wheel wear S; Schneidenschartigkeit R_K = smoothness of cutting edge R_K; D-Koernung = diamond mesh size; Schleifscheibenverschleiss ΔH_s = grinding wheel wear ΔH_s; Rauhtiefe R = surface finish R; D-Koernung = diamond mesh size; D-Konzentration: 2 ct/cm³ = diamond concentration: 2 ct/cub cm; HM-Sorte: S1 = sintered carbide type: S1; Schneidkeilwinkel β 90° = cutting rake angle β = 90°; Schleifgeschw.: 18.4 m/s = grinding speed: 18.4 m/sec; Anpresskraft: 800 g = pressure 800 g; Flaechenpressung: ~ 10 g/mm³ = surface pressure: ~ 10g/sq mm; Schleifzeit: 60 min = grinding time: 60 minutes.*

becomes less with further grinding. By means of microscopic examination, of which the diagrammatic representation has not been attempted here, whole diamond grains were observed to break out of the grinding zone of the wheel, especially at the beginning of the experiment, *ie* with freshly trued wheels, and the presence of diamond grains in the grinding swarf was observed. These examinations confirmed the conclusions drawn from the course of the curves

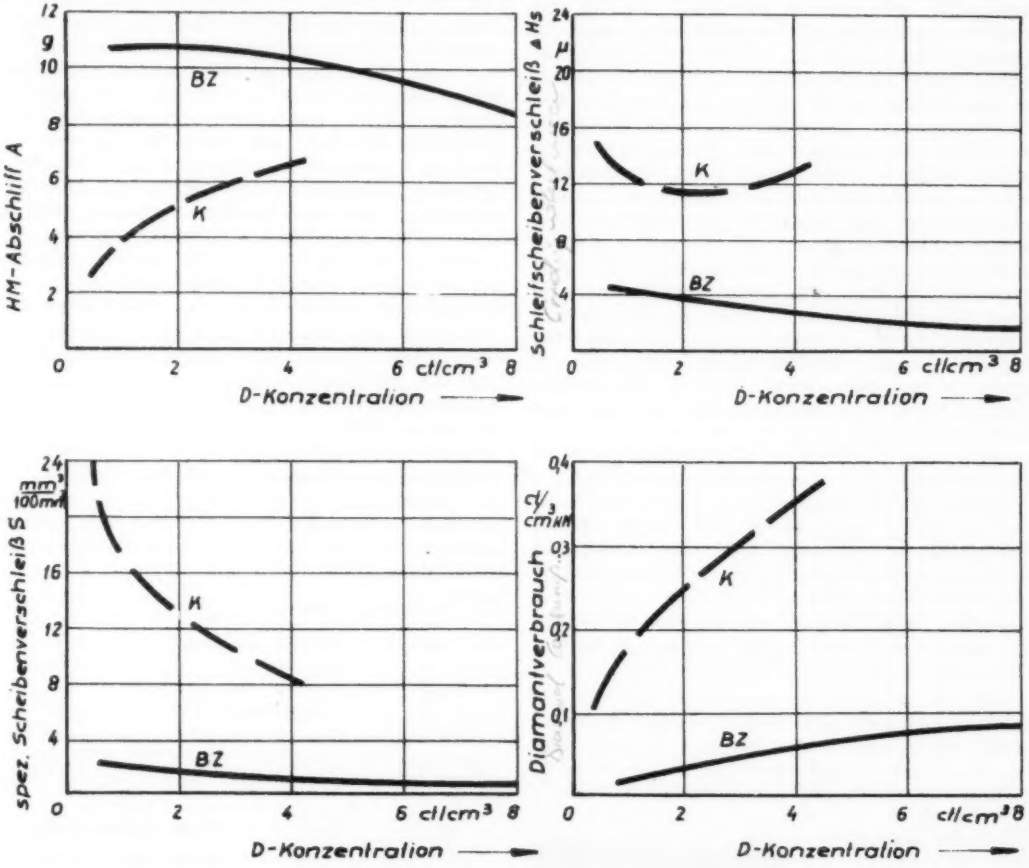

Fig 5. *Sintered carbide abrasion, grinding wheel wear, and diamond consumption in relation to the diamond concentration for bronze- and resin-bonded diamond grinding wheels.*
Translation: *HM-Abschliff A = sintered carbide abrasion A; spez. Scheibenverschleiss S = specific grinding wheel wear S; D-Konzentration = diamond concentration; Schleifscheibenverschleiss Δ H_s = grinding wheel wear Δ H_s: Diamantverbrauch = diamond consumption; Auf die Rautiefen der Flaechen und auf die Schartigkeit der Schneidkanten hat die Diamantkonzentration keinen Einfluss = the diamond concentration has no influence on the surface finish or on the smoothness of the cutting edge; D-Koernung: D 50 = diamond mesh size: D 50; HM-Sorte: S1 = sintered carbide type S1; Schneidkeilwinkel β 90° = cutting rake angle β 90°; Schleifgeschw.: 18.4 m/s = grinding speed: 18.4 m/sec; Anpresskraft: 800 g = pressure: 800 g; Flaechenpressung ~ 10 g/mm² = surface pressure: ~ 10 g/sq mm; Schleifzeit: 60 min = grinding time: 60 minutes.*

with reference to the wear and blunting properties of a diamond grinding wheel, independently of the grinding time.

The mesh size of the diamond grinding wheel was examined between D7 and D100. Fig 4 shows the influence of the grain size on the grinding results. The grinding time was 60 minutes. An increase in the abrasion was noticed only up to certain grain sizes (Fig 4A), for the number of the grains concerned in the grinding process decreases with increasing grain size. The research of Engdahl-Wassby[3] produced similar results. The decrease of the absolute wear ΔH_s (Fig 4B) after a certain grain size has been exceeded can be attributed to the fact that diamond grains with a bigger diameter are more firmly anchored in the bond and have a greater loadability. Under the given conditions a BZ wheel of mesh size D 50 produced the greatest sintered carbide abrasion, and thus had the smallest specific grinding wheel wear. The K wheel, on the other hand, showed the greatest abrasion, with a mesh size D 100, and the least specific wear. In order to obtain the greatest possible sintered carbide abrasion with a specified diamond and bronze or resin bond, BZ wheels should be used with a mesh size of D 30 to 50 and K wheels with a grain size of D 100 and coarser. Surface finish and edge smoothness decrease with increasing diamond grain size of the grinding wheel (Fig 4D and 4E).

For the diamond concentration of the wheel, examined in the range of 0.5 to 8 ct/cub cm, the following was proved, according to Fig 5.

With BZ wheels the abrasion is less, as the pressure is distributed among several diamond grains, which causes the surface pressure, and also the possible attack of an individual grain, to be less. More highly concentrated K wheels show, however, a greater abrasion, which must be the result of the wear of the K bond and the resulting self-sharpening of the wheel, by means of which new sharp diamonds are continually exposed (Fig 5A). It is especially interesting that the diamond consumption alone rises with stronger diamond concentration for every cubic centimeter of ground sintered carbide (Fig 5D). An increased diamond concentration therefore brings with it a rise in the expense of the grinding process. This is particularly true with K wheels, where the absolute wear value (ΔH_s) rises yet more once a certain concentration has been exceeded (Fig 5B). With BZ wheels a greater quantity of diamond leads to a smaller absolute wear value, and thus to a greater working life, which is an advantage with profile grinding wheels. The diamond concentration has no influence on surface finish and smoothness.

Further experiments, which will not be discussed here, treated the difference between dry and wet grinding with various coolants, and the difference between types of sintered carbide with the same DIN specification. The theory put forward by Heiss[4] on cutting was compared with these results and experimentally examined. Also the sharpening of the cutting edge and the connexion between smoothness and carbide structure is dealt with. A further paper will treat this subject.

Note.—All references will appear at end of article.

To be continued.

Conversion Chart

A strength, hardness, and temperature conversion card, in a perspex cover to protect it against oily palms, is available on request to the Mond Nickel Co. Ltd., Thames House, Millbank, London SW 1.

Sign of the Times

According to the *Irish News*, New Zealand's ancient craft of greenstone carving has been revived after a lapse of about a century. Formerly a Maori craft, in which a sand and water slurry was used as the abrasive, greenstone is now worked with diamond drills and grinding wheels. The greenstone inkstand shown here was produced by Mastercrafts Ltd., the Auckland firm of manufacturing jewellers.

Finishing Aluminium Valve Bodies with Diamond Tools

by **John Waller**

Leakproof assemblies where gaskets are forbidden can present a production problem unless the two mating surfaces are perfectly flat and free from any suspicion of roughness left by the orthodox facing tools. There are frequent occasions when designs of this nature arise—hydraulic boxes are a typical instance of this form of construction—and the application of diamond tools eventually overcame the need for considerable lapping time, and introduced a higher degree of finish than that obtained with carbide tipped tools.

Machining set-up

As most of these surfaces are not generally machinable by passing a tool across in the manner practised when operating a lathe cross slide, milling is essential, and the machine tool chosen for this particular operation was a Victoria Model V4 miller from the range of Messrs B. Elliott & Co Ltd., of London. The following characteristics of this machine are perhaps of interest; it was selected because of the massive design and the fact it had a top spindle speed of 1,000 rev/min, coupled with a feed of about 0.001 in./revolution. The design of the cutter head followed the usual methods employed with these articles: a large taper fitted the machine spindle, and this was accurately ground to rotate concentrically with the bore of the large disk. This latter item was then bored to receive the diamond tipped tools, care being exercised to maintain concentricity of the tools by carefully jig boring the necessary holes locating from the central bore. Thus, despite, the fact that the cutting members weigh but a few ounces, there is little possibility of eccentricity creating vibration. An overhaul of the machine's bearings is deemed advisable if the machine is rather old, and a general tightening up of the slides is also needed; in other words, steps are necessary to promote absolute rigidity if the cutter head is to give an ideal performance and produce the desired result.

Fig 1 illustrates the constructional methods adopted. Eight tools are introduced, spaced at regular intervals round the periphery of the blank. If the solid style of blank is preferred, a welded design is perhaps the easiest to undertake, and in this instance the tapered shank is secured by a rim of weld material in a vee made by the two parts as seen in Fig 2. Thus if a final grinding operation is made after the central hole has been bored, final rotation is properly secured. However, in both cases accurate spacing of the tool is deemed an essential feature of the design.

Type and arrangement of diamond tools

Diamonds up to 1 carat are set in holders as illustrated at Fig 3. The holders are made from lengths of Jessop Saville 1% chromium case hardening steel which is suitable for stress up to 45 tons/sq inch. A light case-hardening process is useful for such items as this prevents the usual damage to the surfaces when holding screws are tightened; temperatures of about 900 deg C for carburizing and 800 deg C for hardening give a suitable surface.

The enlarged drawing indicating the diamond angles shows the views needed for their manufacture, and for the fitting of the stones the contact surfaces were initially lapped to ensure an even and firm seating. Similarly the shank of the holder is provided with a flat—again ground to ensure a correct dimension from the centre line, and if the diamond slots are located from this flat

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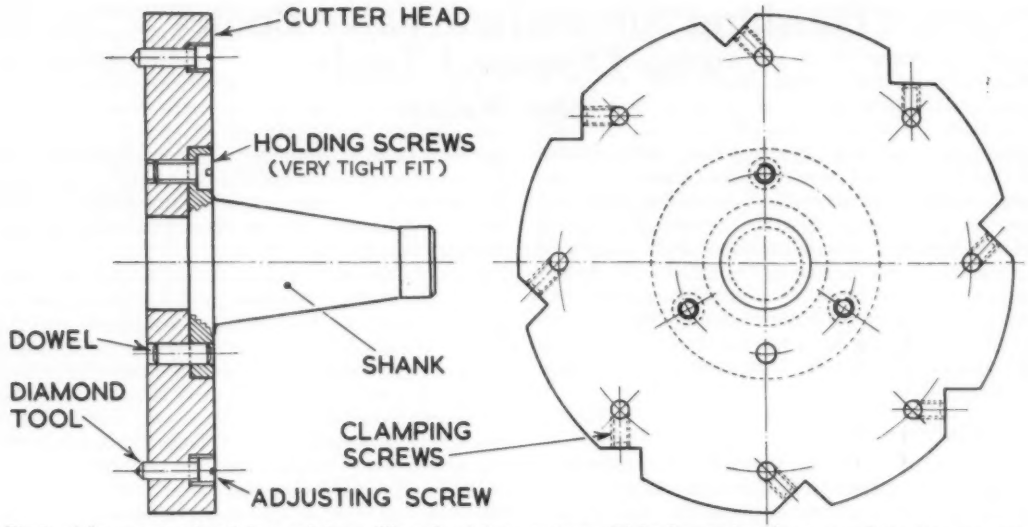

Fig 1. A large cutter head designed for milling aluminium castings. Eight diamond tools set round the face are carefully spaced in order to preserve the balance of the cutter.

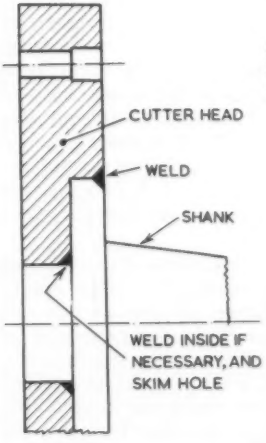

Fig 2 (left). Welding the parts of the blank is possible by machining a vee for the weld material. A generous vee is desirable.

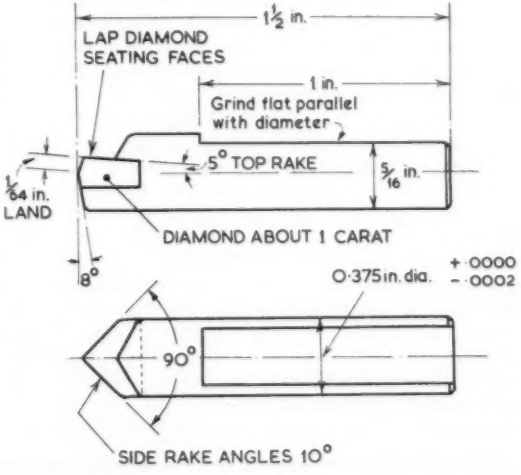

Fig 3 (right). An enlarged view of the diamond insert indicating the different cutting angles and the prominent flat on one surface which is useful for setting purposes.

all tools are eventually identical so far as placing the stones is concerned. Boring the holes and grinding the holders to close tolerances—a limit of +0.0005 in. and —0.002 in. on the hole diameter—is sufficient to ensure that the parts slide together whilst the assembly remains virtually a solid one.

Utilizing the formula $\pi \times D \times N$ where D is the cutter diameter and N equals the number of revolutions of the work spindle, the number of ft/minute is

$$\pi \times D \times N = \frac{22}{7} \times \frac{9}{12} \times \frac{1000}{1} = 2{,}360 \text{ ft/min}$$

and this speed is, in fact, much too slow for the really efficient presentation of this process, and a surface speed approximating 6,000 feet/min is more in keeping with the use of these tipped tools. However, the finish secured was of a high order and averaged 8 micro-in. using this speed with a feed of about 0.001 in.

As these components are die cast, the amount of material removed from the surfaces by this process is only 0.03 in., and this is broken down to 0.025 in. for rough machining using the usual carbide tipped tools, the final skim with the diamond tools removing 0.005 inch.

Design points

Other points of interest in the design are the rear grubscrew for moving the tool forward to obtain an accurate setting of each member, and the fact that the holders are always set well back in the disk. The latter method is, of course, good workshop practice, as this provides the closest of support to the cutting edges and is yet another step towards the rigidity which is so essential for the high finish desired. Setting the tools also requires care as each should match the preceding member; failure to achieve the desired setting means that there is a possibility of one tool doing more than its fair share of the work. Fig 4 shows a typical workshop set-up for cutters of this class, and there two parallel strips are used on which the disk is placed. Each diamond tool is then pushed gently downwards by means of the grubscrew until each just touches the face on which the parallels seat. *Care is emphasized* as too heavy a pressure on the screw is likely to create damage to the edges of the stones, and perhaps a better method is to press each down lightly with the fingers and re-insert the grubscrew; the latter is then threaded downward until the key used for this process is again finger-tight. Each holder is then clamped by the side screws and will not move under the influence of the cutting action.

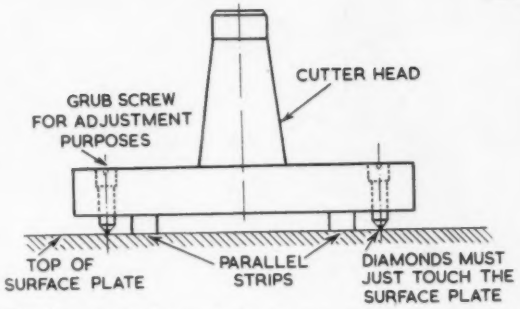
CUTTER HEAD
GRUB SCREW FOR ADJUSTMENT PURPOSES
TOP OF SURFACE PLATE
PARALLEL STRIPS
DIAMONDS MUST JUST TOUCH THE SURFACE PLATE

Fig 4. Setting the tools is an easy process if two flat parallel strips exactly the same thickness are employed. Gently pushing the holders with the fingers is advisable for this operation in order to avoid chipping the stones.

Demonstration of 'Lapmaster' Lapping Equipment

The Hounslow premises of Payne Products International Limited were opened to the trade from November 10 to 21. Lapmaster models 12, 24, and 36 were demonstrated.

The Lapmaster principle

The Lapmaster 12 (over page) is the smallest in the Lapmaster range, and it works on exactly the same principles as the large models. The operating sequence is as follows : the agitator tank (1) is filled with the lapping vehicle and compound in the proportions required, and the agitator switch (2) is turned on. This starts the agitator in the tank and mixes the abrasive (aluminium oxide or sintered carbide) with the oil vehicle. Compound valve switch (3) is then turned to the ' on ' position. Timing clock (4) is set to the desired time cycle and starts lapping plate (5), at the same time opening compound valve (6) which allows the lapping compound to flow down the conductor track to the side of conditioning ring (7). The rotation of the conditioning rings on the lapping plate distributes the compound. The action of the replaceable Meehanite conditioning rings conditions the lapping surface throughout the whole of the work cycle. At the end of the predetermined lapping time the clock stops the lapping plate and closes the compound valve.

Aluminium oxide is the abrasive normally used with the Lapmaster, but silicon carbide is also suitable for some applications. Where a particu-

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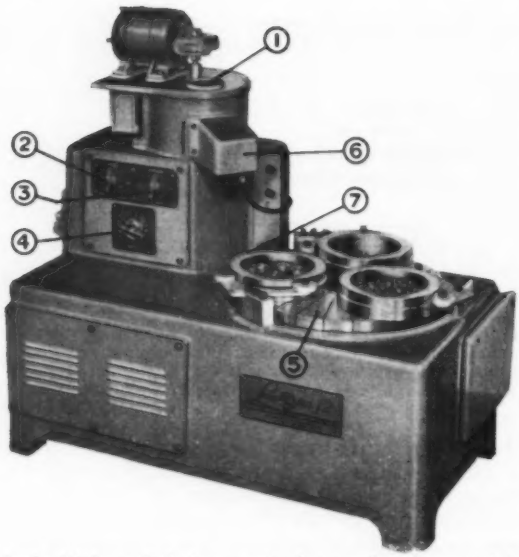

larly high polish is required on a hard material, *ie* tungsten carbide, diamond is used; this, however, is only in rare cases. Finishes below 1 micro-in. rms are readily attainable, and a flatness within one light band is produced.

Models available

Lapmaster models 12, 24, and 36 have been available for some time now, and from January 1959 the range is to be extended to include the Lapmaster 48. Other models available in the United States, and in Great Britain by special order, include the 72 and 84. The Lapmaster 12 is the most widely used model in the precision field; it is suitable for lapping silicon and germanium wafers for use in transistors, and is already in wide use in this country. A special attachment is available for use when lapping the crystal wafers. One side is first lapped conventionally to a flatness of approximately two light bands (0.0000232 inch). This side of the wafer is then fixed to the base of the attachment (also flat within two light bands), which is in the form of a triangular steel plate with three diamond-tipped adjustable micro-thread legs. The legs are set so that a length of leg equal to the desired thickness of crystal wafer protrudes below the base of the plate. Accurate setting of the legs is facilitated by a setting gauge. The accessory is then placed on the Lapmaster 12, and the wafer is lapped until the diamond points touch the lapping plate. As the aluminium oxide abrasive cannot lap diamond, no further lapping of the wafer takes place.

Surface finish tester

The Diavite-Microtester, also shown at the exhibition, is a surface finish tester with a hydraulically operated diamond stylus in the probe. The meter reads from 0 to 300 micro-in. CLA, and the stylus stroke on the model shown was 8 mm. Different models are available with stylus strokes from 1 to 12 mm. The diameter of the probe shown was 8½ mm, and probes down to 4 mm in diameter can be obtained.

Diamond Hones in Australia

Our note on Diagrit diamond hones [*IDR* 1958 Vol 18 (214) pp 176-177 (Sep)] has prompted Diamond & Boart Products (Australia) Pty. Ltd., to send us a note on the diamond hones produced by their company, as used by the International Harvester Co., of Geelong.

The roughing hones use 85 mesh diamond and are used on a Micromatic honing machine, the head of which operates at 172 rev/minute. The bores honed range from 3 9/16 to 4¼ in. diameter, by 7 to 9 in. long. Stock removal is 0.004 to 0.005 in. in 20 to 25 strokes. Bores are diamond honed to within 0.0008 to 0.0012 in. of size, which is within 0.0003 in. of ovality and taper. The hones are used with refrigerated 'Solvent F', produced by the Vacuum Oil Company. This must be applied at a rate of 6 gall/minute.

CORRECTION

On page 218 of the November issue we referred to the use of diamond in the US motor car industry. It was suggested that this industry would probably use some 10,000,000 carats of diamond each year. This should have read $10,000,000 worth of diamond.

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